

BELLCOMM. INC.

SUBJECT: Transmittal of Bell Telephone
Laboratories Memorandum on
Modifications to the Voice
Conferencing Arrangements at KSC
Case 320

DATE: June 16, 1967

FROM: J. Z. Menard

Mr. W. E. Parsons - NASA/MJ:

The Bell Telephone Laboratories has prepared the two attached memoranda which contain (1) a written description of their suggested plan for converting critical launch circuits from 2-wire to 4-wire in the OIS(A) conference circuits at KSC and (2) a description of the implication of the more efficient headset transducers used in (1) on the 2-wire portion of the OIS(A) system. This material supplements that which was given in the original oral report by BTL on May 3, 1967 in Holmdel, New Jersey. It is our opinion that sufficient detail is included in these combined memoranda to permit implementation of the suggested system by a competent contractor.

After you have had the opportunity to review the material in the attachments, we will hold a meeting at BTL, Holmdel, New Jersey to review your comments and questions.

J. Z. Menard
J. Z. Menard

2034-JJH-ew

Attachments

Copy (with attachment) to
Messrs. T. A. Keegan - NASA/MA-2
W. E. Miller - NASA/MOG

E. D. Stone - KSC/QG-6

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Copy (without attachment) to
C. C. Kraft, Jr. - MSC/FA
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F. T. Andrews, Jr. - BTL

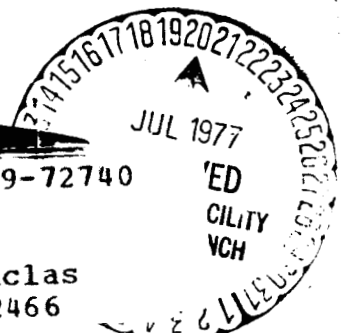
D. Gillette - BTL

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~~X67-74-113~~
(NASA-CR-154326) TRANSMITTAL OF BELL
TELEPHONE LABORATORIES MEMORANDUM ON
MODIFICATIONS TO THE VOICE CONFERENCING
ARRANGEMENTS AT KSC (Bellcomm, Inc.) 48 p

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ATTACHMENT A

A PLAN FOR MODIFICATION OF CONFERENCING ARRANGEMENTS AT KENNEDY SPACE CENTER

General

At the present time 2-wire conferencing arrangements are used extensively at the Kennedy Space Center. These are illustrated in Figure 1. Bellcomm recently requested the Bell Laboratories to outline a plan for providing more reliable arrangements for certain critical circuits. This memorandum describes a plan suitable for improving these critical conference circuits. The sections that follow suggest those things which should be done for this particular plan to succeed in the event that it is selected by those responsible for implementation.

The plan is based on the use of 4-wire, low impedance bus bar techniques for the more critical conferences. Two-wire operation is retained for the less critical conferences. Station operation for both the 2-wire and 4-wire circuits is the same as at present.

General Conferencing Layout

The suggested 4-wire conferencing arrangements for use at the Cape Kennedy Space Center is illustrated in Figure 2. The conferencing configuration can be visualized as a hub consisting of the 4-wire bridges and radiating to the bus bar bridges located at the various complexes and buildings, to long distance circuits (such as Houston), the 304 Switching System, and to the local OIS-RF system. All of the interconnected circuits are 4-wire, permitting full-duplex operation all of the time.

Operation of the 4-wire bridges, the 304 Switching System, and the OIS-RF are described elsewhere. This memorandum will concern itself mainly with a description of the bus bar conference bridge, its transmission aspects, and a suggested method for implementing it.

Primary Bus Bar Conference Bridge

The suggested method for providing 4-wire conferencing uses a low impedance 4-wire bus bar arrangement. The general

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layout of this arrangement, which permits conferencing many short-haul 4-wire circuits, is illustrated in Figure 3. The bridge consists of low impedance transmit and receive buses interconnected with two parallel amplifiers, (A) and (B), to provide talking capability between the buses. Each area* of the complex is connected to the buses through isolating resistors as indicated. Within these areas, there are patch distributors (P/D) from which the circuits branch out through additional isolating resistors to the several stations connected to each branch.

Any station connected to the transmit bus is able to talk to any other station connected to the receive bus through amplifier (A) or (B). For example, speech from station 1 will be transmitted through amplifiers (A) and (B) to receivers of stations 1, 2, 3, etc. Similarly anyone else talking into a microphone connected to the transmit bus will be heard on any receiver connected to the receive bus. Sidetone for the receiver of a station is also transmitted through bridge amplifiers (A) and (B). Thus, the sidetone of an average talker is at the same level as the speech received from other average talkers. With this method of providing sidetone, the round trip delay between the microphone and its own receiver should not be more than about 15 milliseconds. This is well within the delays expected at any on-base installation.

When someone talks on the bus bar bridge, his speech will also be transmitted through amplifier (C) to the 4-wire hub bridge for transmission to other primary bridges on the base and to off-base locations. Speech incoming from the 4-wire hub bridge which originates at other primary bridges and off-base locations will be transmitted through amplifier (D) and heard by all listeners connected to the receive bus.

Isolation resistors at the bus bar and at branching points, in both the transmit and receive legs, are used to minimize any adverse effect on transmission in case a short circuit or a trouble ground develops on a line interconnecting the stations with the conference bridge.

* An area includes all stations connected to the same outgoing leg from the audio switch panel.

Low impedance bus bars are used for the conference bridge to reduce transmission level changes to unnoticeable amounts as stations are connected to or removed from the conference bridge. This makes it unnecessary to provide idle circuit terminations.

Two amplifiers, (A) and (B), are used in parallel to prevent total conference failure in case one amplifier fails. Amplifier (C) provides transmission toward the 4-wire hub bridge, and amplifier (D) provides transmission from the 4-wire hub bridge. The input impedance of amplifiers (A), (B), and (C) is about 1.5 ohms each, and, in parallel, result in a transmit bus bar impedance of about 0.5 ohm.

The outputs of amplifiers (A), (B), and (D) are connected in parallel and transmit into a voltage divider consisting of two series 1.47 ohm resistors and two 1.0 ohm resistors in parallel. The receive bus impedance thus is less than 0.5 ohm, because, in addition to the two parallel 1.0 ohm resistors, three amplifier output transformers (about 1.6 ohms each) and the series 1.47 ohm resistors are bridged across them. The effect of the impedance of the stations and isolating resistors is negligible. Each amplifier is therefore feeding a load of about 3.4 ohms. Voltage dividers are used to provide a low impedance bus and the proper transmission level to the receive amplifiers. All series resistors also act as isolating resistors to minimize adverse effects if a trouble condition develops in an amplifier.

To obtain the maximum signal to noise ratio at the output of the amplifier, it should be operated at the highest available output. To provide proper receiver output, the voltage dividers, as explained above, are used to furnish the correct level to the headset receiver amplifiers.

The output of amplifier (C) and the input of amplifier (D) are 600 ohms, since they connect to the 600 ohm legs of the 4-wire hub bridge.

Consideration has been given to providing a primary bridge at the 4-wire hub bridge locations and secondary bridges at the launch complexes and in other buildings requiring 4-wire conferencing. However, this would not be as desirable from

a system reliability standpoint as providing primary bridges at these locations. With this arrangement, a complex may operate individually in the event of cable failure. If desired, it is also possible to provide protection between complexes as described later and illustrated in Figure 5.

Secondary Bus Bar Conference Bridge

When the low impedance bus bar is extended to another building (for example, the AGCS building), a new bus bar should be established at that location. As shown, the secondary bus bar is served by amplifiers (E) and (F). For protection purposes, these amplifiers may be paralleled with another set of amplifiers in a manner similar to that shown for amplifiers (A) and (B) (see Figure 5).

As illustrated in Figure 4, the input to amplifier (E) is used to establish the low impedance transmit bus of the secondary bridge in the remote building. The output of amplifier (E) is used to couple the new transmit bus to the primary bus bar bridge through isolating resistors. The input to amplifier (F) is connected from the primary receive bus bar through isolating resistors. The output of amplifier (F) is terminated in a voltage divider to establish a new low impedance receive bus in the remote building.

When anyone talks at the secondary bridge, the speech will be transmitted through amplifier (E), then through amplifiers (A) and (B) to the primary receive bus and returned to the secondary bridge receive bus through amplifier (F). The talker will also receive his sidetone through the same path. His speech will be transmitted off complex through amplifier (C) to other locations.

When a party connected to the primary bus talks, his speech will be transmitted through the (A) and (B) amplifiers and through the (F) amplifier to all listeners connected to the secondary bridge receive bus. When someone talks off complex, his speech will come through amplifiers (D) and (F) and be heard by all listeners connected to the secondary receive bus.

Amplifier (E), whose input impedance is 1.5 ohms, is terminated in 1.47 ohms. This provides a secondary transmit bus input impedance less than 1 ohm. (If two amplifiers are connected in parallel, this resistance should be removed.) The output impedance of amplifier (E) is 600 ohms and feeds the primary transmit bus through two 300 ohm isolating resistors located at the primary bus. Amplifier (E), in addition to making up the loss of the low impedance bus, is used to make up

the loss of the cable between the primary and secondary bridges.

Amplifier (F), whose input impedance is 600 ohms, is fed from the primary receive bus through two 300 ohm isolating resistors located at the primary receive bus. The 3.2 ohm output of amplifier (F) feeds the low impedance secondary receive bus through the voltage divider consisting of two 1.47 ohm resistors and two 1 ohm load resistors in parallel.

Feeding the Spacecraft from the Bridge

We understand that the spacecraft communication system connects to the conference on a 2-wire basis and the speech level from the spacecraft is lower than that received from the stations. Furthermore, we understand that the spacecraft must be furnished a higher speech level than is needed at the stations.

It is possible, as suggested below, to use the gain of amplifiers (E) and (F) to compensate for these different levels. The 600 ohm input of (E) amplifier can be fed directly through isolating resistors and proper pads from the spacecraft. The output signal to the spacecraft can be taken off the 600 ohm output of the (F) amplifier, using the proper isolating resistors and pads. These pads will have to be carefully worked out and the low impedance bus bar input and output levels properly compensated for the extra loading.

To take advantage of these higher levels, it will also be necessary that the return loss from the spacecraft be correspondingly increased.

Additional Service Protection

As illustrated in Figure 5, in addition to paralleling the (A) and (B) amplifiers, which is the minimum suggested service protection, it is possible to parallel amplifiers (E) and (F). Furthermore, an additional talk-back amplifier may be provided for the secondary bridge to be patched on an emergency basis if the cable between the primary and secondary bridges should open inadvertently.

To protect the system if the cable between a complex and the 4-wire hub bridge fails, an emergency patch arrangement could be provided between complexes as illustrated in Figure 5.

Cabling Layout

To understand the cabling layout in a launch complex and the suggested changes that will be required when a conference circuit is changed from 2-wire to 4-wire operation, a brief review will be made of the present cabling layout. This layout is illustrated in Figure 6, which gives an outline of the arrangements in Launch Complex 34 (LC34). The conference circuits enter the blockhouse from the 4-wire bridge on a 4-wire basis. At this point, each terminates in send and receive (AIA) amplifiers and a voice operated switch (VOX) which is used to convert the circuit to 2-wire operation. There are 42 of these 2-wire circuits which enter the blockhouse and are extended through the audio switch panels (ASP). In each of these units there are keys which are used to isolate the individual conference circuits as they branch out into eight areas within the complex. From the (ASPs), the conference circuits are carried through patch distributor (P/D) units as indicated. Eight station branches,* each containing a cable for twenty-one 2-wire conference circuits, emanate from each P/D unit.

Each one of the 42 conference circuits appears in pin jacks in the P/D unit. These permit patching, as required, to various station branches. The station branches include from one to about ten 2-wire stations bridged directly across the 2-wire line. Each station consists of a receiver-amplifier working into a receiver, and a microphone working through a microphone-amplifier connected to the 2-wire line as indicated. There is also a monitoring amplifier included in the station unit. At the station any one of the connected 21 conference circuits can be selected by the operation of the ACTIVE selector switch which connects the microphone and the receiver with their associated amplifiers to the desired conference. The MONITOR switch is used to select any one of the 21 conferencing circuits for monitoring purposes. Other station branches are similarly connected from this and other P/D units around the complex.

The arrangements at the Automatic Ground Control Station (AGCS) are also shown in Figure 6. The branching-out procedure from the AGCS is the same as described previously for the blockhouse.

* A station branch includes all stations connected to a patch module of a patch distributor.

Figure 7 illustrates, in a general way, the physical layout of the various control and patching units. The only additional units which were not described previously are the audio bus panels. These panels are used to bus different conferences. In 4-wire operation it will not be permitted to bus any 4-wire conferences, hence the wiring to the audio bus panel for all 4-wire conferences will have to be disconnected.

At present the 2-wire sides of the AIA amplifiers are connected to a particular patch distributor panel and each is brought into an audio switch panel through a cutoff key. On 4-wire conferencing circuits the (AIA) amplifiers should be disconnected.

Implementing the 4-Wire Bus Bar Bridge

Figure 8 illustrates a suggested method for connecting the Bus Bar Bridge to the Audio Switch Panels (ASP) and to the Patch Distributor Panels (P/D). A more detailed sketch showing the audio switch panel is shown in Figure 9. The information contained in these figures applies to primary bridges located in launch complexes or buildings such as the MSOB as well as to secondary bridges located in the AGCS building.

Each 2-wire branch of a conferencing circuit is connected to a 3-position switch. In the center position, the branch is terminated in a 620 ohm resistor but the stations on the branch may still talk with one another. UP and DOWN bus bars are available to connect together branches of a conference circuit into two separate conferences. For 4-wire conference operation, it is suggested that the UP position of the switches in the ASP should be used to connect the areas to the conference bridge and the DOWN position of the switches to connect the areas to a Test Panel. This suggested method of operation will permit ready means to isolate troubles by use of the test panel.

Isolating resistors should be used for each branch emanating from the ASP. These resistors will protect the bus bar from short circuits or false grounds on the cabling between the ASP and the P/Ds.

The cables from the ASP fan out through patch distributor panels to the station branches and finally to the individual

stations. Additional isolating resistors should be installed in each station branch as it fans out from a P/D. These resistors will protect other station branches from short circuits or false grounds in stations or in the cabling of a branch circuit.

Audio Switch Panel and Patch Distributor Circuit Modifications

Figure 8 illustrates schematically the circuits of the Audio Bus and Audio Switch Panels. For every 4-wire circuit, two 2-wire circuits should be used. The suggested changes in the Audio Switch Panels are shown here. Connections to the Bus Panel should be removed to prevent any unauthorized interconnections. As previously mentioned, the UP bus bar should be used for the conferencing bridge and the DOWN bus bar for testing of the area circuit. The same wiring changes should be made in all audio switch panels containing 4-wire conferencing circuits.

For every 4-wire conference bridge, the cabling for two 2-wire conferences will be used. One of the 2-wire circuits should be used for the receive bus of the conferencing bridge and the second 2-wire circuit for the transmit bus. It is suggested that the connections to the amplifiers be made through jack J11 of the last audio switch panel and connections to the test panel through jack J12.

Isolating resistors should be provided in each leg of the low impedance bus of the 4-wire conference bridge. The value of each resistor should be 150 ohms. One percent resistors with good aging and stability characteristics should be used. A suggested method of inserting these resistors is shown in Figure 8. Each leg is also terminated in 300 ohms $\pm 1\%$. The value of the isolating resistors in the P/Ds should be 150 ohms $\pm 1\%$ resistors for the transmitting legs and 300 ohms $\pm 1\%$ for the receiving legs, as shown in Figure 8. These isolating resistors, which protect the conference bridge and the branch legs of an area, may be installed either in the patch cords or in series with the output patch jacks in the P/D. Mounting these resistors in series with the input patch jacks could be done if there is only one or, at the most, two station branches distributed from the P/D.

Terminating Station Changes

The proposed plan will permit operation with both 2- and 4-wire conferences with automatic changeover between types of

conferences. Station operation will remain the same. To make these wiring changes in the station sets, the 2-wafer, 2-deck ACTIVE switches should be replaced with 2-wafer, 4-deck switches at all locations where 4-wire operation is required.

Figure 10 illustrates the wiring changes that are required at locations where 4-wire operation is necessary. In this figure, only one 4-wire and two 2-wire circuits are shown. If more than one 4-wire circuit is required, the wiring will be similar and two 2-wire conferencing circuits will be used for each 4-wire conference.

The switch suggested for this purpose is illustrated in Figure 11. To provide four decks, both sides of the wafer are used to mount lugs. Because of this, it is necessary to use one of the lugs as the connection to the rotor blade leaving 23 positions for conference connections. To make the operation of this switch the same as previously, the twenty-fourth position should be used as the off-position. The rotor in this case should be connected to the twenty-third lug providing 22 usable positions. The off-position may be terminated in 620 ohms if desired.

If it is desired to make available 23 usable positions, the twenty-fourth lug could be used for the rotor and off position. In this case, the 620 ohm termination would not be used.

At the present time, the ACTIVE and MONITOR switches use bridging (also referred to as shorting) contacts to prevent oscillation of the interconnected microphone and receiver amplifiers. With bridging contacts, it is possible to interconnect two conferences if the switch is stopped half-way between lugs. Even if the switch rotation is not positioned between lugs, momentary interconnection of two conferences results, which could cause a short interfering signal on both conferences. This would increase the noise level on the conference circuits when there is a great deal of switching activity. Since the microphone and receiver amplifiers are not connected together at stations where 4-wire conference circuits are used, it is possible to provide a nonbridging ACTIVE switch. The design engineer must investigate this further to assure that no oscillation of the amplifiers will result while the switch is in the interlug position. Preliminary tests indicate that shielded wiring should be used between the amplifiers, the intercom switch and the ACTIVE switch rotors to minimize the chances of singing.

Further tests indicate that any oscillation that occurs while the switch is between lugs will be damped instantly when a circuit connection is completed. Consequently no interfering noise will be detected on the connected circuits. However, to repeat, before the nonbridging switch is specified, the design engineer should perform further tests to assure that this type of operation is satisfactory.

The possibility of acoustic shock exists in the system as presently used. With the introduction of a more efficient receiver this possibility will be increased. It is therefore suggested that some means be incorporated to eliminate this condition.

Intercom Use

The present intercom switch has a simple transfer circuit which disconnects the headset and its associated amplifiers from the selector switches and connects them to the intercom circuit. When a station is modified for 4-wire conferencing, the microphone and receiver amplifiers are disconnected from each other. When the intercom switch is operated for this arrangement, the microphone amplifier is connected to the intercom circuit and disconnected from the rotor of the ACTIVE switch. The receiver amplifier is not connected to the intercom circuit and there is no sidetone. If the loudspeakers of the intercom set do not prove a satisfactory means for checking whether the intercom is busy, and if sidetone is desired, it will be necessary to replace the intercom switch. The new switch should provide additional contacts which will interconnect the microphone and receive amplifiers, and cut off the switch rotors during intercom use as indicated in Figure 10.

Transmission Plan and Circuit Line-Up Procedures

The suggested transmission plan is shown in Figures 3 and 4 and the circuit line-up procedures are shown in Figures 12 and 13. The transmission plan is based on a microphone and microphone amplifier output of -15 vu into 600 ohms for an average talker. Based on standard Bell System line-up procedures for private line systems, this is a transmission level point (TLP) of 0 dB.

The knee of the limiting receiver amplifier input-output curve in terms of the input signal is approximately 0.045 volt, or -25 dBm into 600 ohms. It is desirable to operate the receiver amplifier so that the average talker's speech level is not limited. Since speech peaks are generally about 10 dB

above the measured talker level, the receiver amplifier should be operated at an average speech input level of -35 vu which is a TLP of -20 dB.

The line-up procedure is based on the use of a new headset with an increase in transmitter efficiency of about 13 dB and an increase in receiver efficiency of about 5 dB. If a receiver is provided that has an increased efficiency of about 10 dB, the transmission plan will not change. The increase in efficiency can then be compensated for with the receiver amplifier potentiometer. Complete line-up procedures are detailed in Figure 13. This table shows the suggested line-up details. Some of these levels do not correspond to the TLPs since it is not practical to perform line-up near the amplifier limiting point. All measurements should be made with a balanced measuring set with input impedances of 600 ohms and about 8000 ohms or higher. The chart shown in Figure 13 lists all necessary details of the line-up measurement procedures.

The gain adjustment for amplifiers A and B, measured individually, is 5 dB lower than the level measured when they are connected in parallel.

It should be anticipated that implementation design and testing will reveal the need for some changes in detail.

Return Loss from the Stations and Headsets

Long distance 4-wire circuits will be connected to the 4-wire conferencing bridge. In this type of system, it would be desirable to avoid the use of echo suppressors and this could be achieved if a 40 dB return loss can be maintained at the entry of the primary bridge. To achieve this return loss, the crosstalk coupling for each terminating station and its associated headset should be a minimum of 60 dB. When a push-to-talk switch is operated, the return loss can be reduced to about 50 dB at that station. Therefore, the number of P/T switches operated simultaneously should be kept to a minimum. The return loss through amplifiers (A) and (B) in the reverse direction of transmission should be well over 60 dB.

Noise and Noise Indicator Circuits

The increase in the transmitter efficiency provides noise improvement in two ways. It increases the signal from the

output of the amplifier, causing the signal level to be higher compared with the inherent microphone amplifier noise. The signal level is also increased over noise induced from sources outside of the circuit. These two items improve the signal-to-noise ratio on the system. The increase in microphone efficiency does not help to reduce crosstalk from other circuits equipped with the same high efficiency microphones.

A method for monitoring the conference network for a noisy leg from the 4-wire, 6-way bridges is illustrated in Figure 14. A noise indicator unit may be connected to each of the 4-wire, 6-way hub bridges. The threshold level of the noise monitor may be set at the desired point. When this noise level is exceeded, the indicator unit can be arranged to cause an alarm lamp to light and an audible signal to sound.

To locate the bridge leg introducing the noise, each leg could be disconnected from the conference and monitored using a test panel as illustrated in Figure 15. When the noisy bridge leg is found, the trouble can be referred to the complex where the trouble is located and cleared by the maintenance people. Once the noise is localized at a complex or building, the maintenance people can further localize the source by switching each area to the DOWN bus in the audio switch panel and monitoring it as illustrated in Figure 8.

Apparatus

All amplifiers used in the suggested layout should be equivalent to the KS-16754, List 3 amplifier. This is a limiting type of amplifier with a nominal gain of 67 dB. The input impedances of the amplifier are 1.5, 600 and 2400 ohms, and the output impedances are 3.2, 12, and 600 ohms.

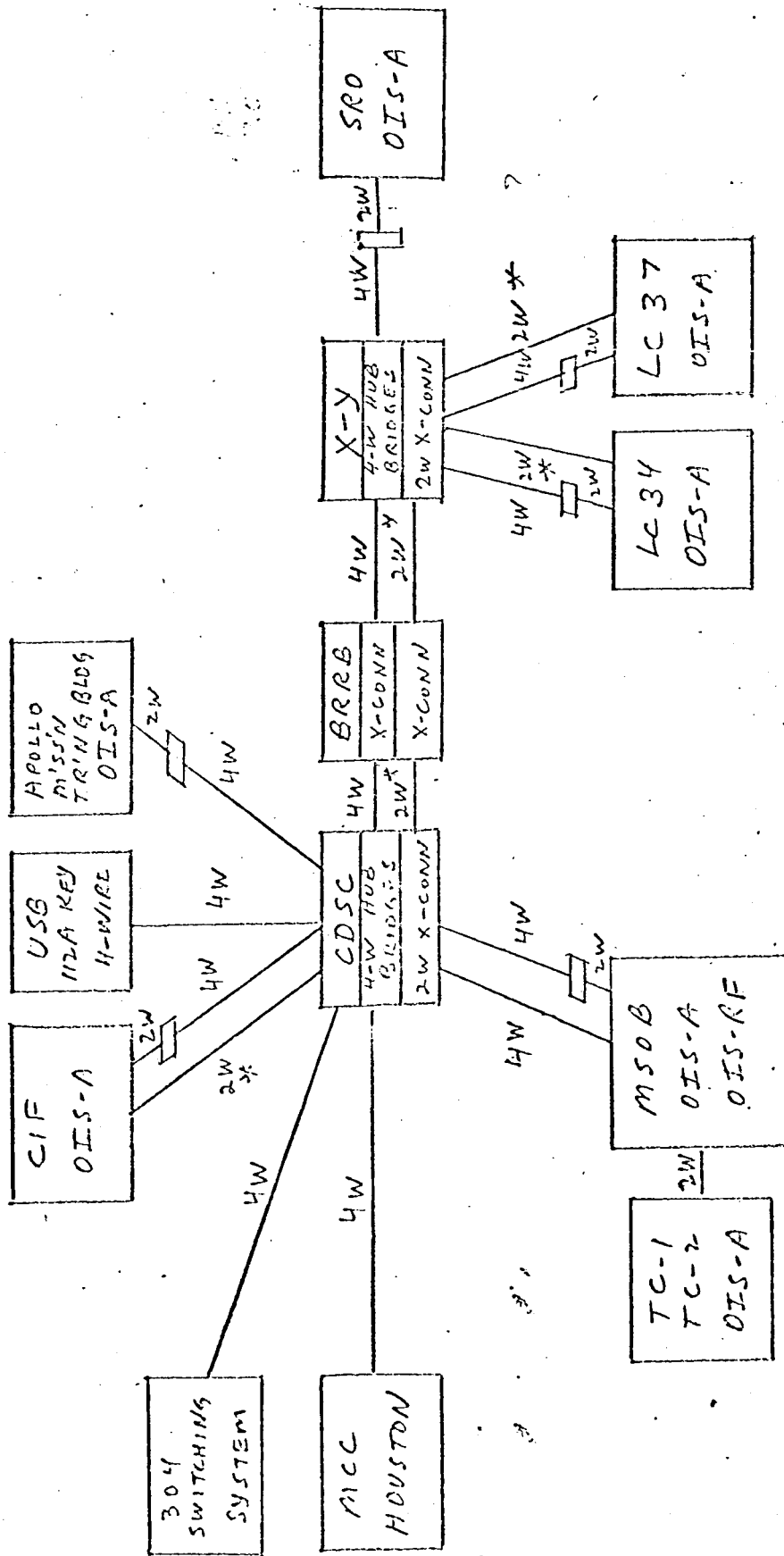
The noise indicator circuit or its equivalent should distinguish between the syllabic character of speech and noise. It should operate on a steady signal. It should not operate on impulse noise unless the noise rate is faster than the syllabic rate of speech. Western Electric J1G012YM and YN units covered by SD-1G166-01 are examples of such noise indicator devices.

Resistors used in this system should have good aging and stability characteristics and they should all have tolerances of ± 1 percent.

Amplifier Patch Jack

The jacks shown in Figure 12 are provided for line-up purposes. No attempt has been made in this document to show the jacks

necessary for patching out defective amplifiers. The design engineer should provide these jacks as deemed necessary.

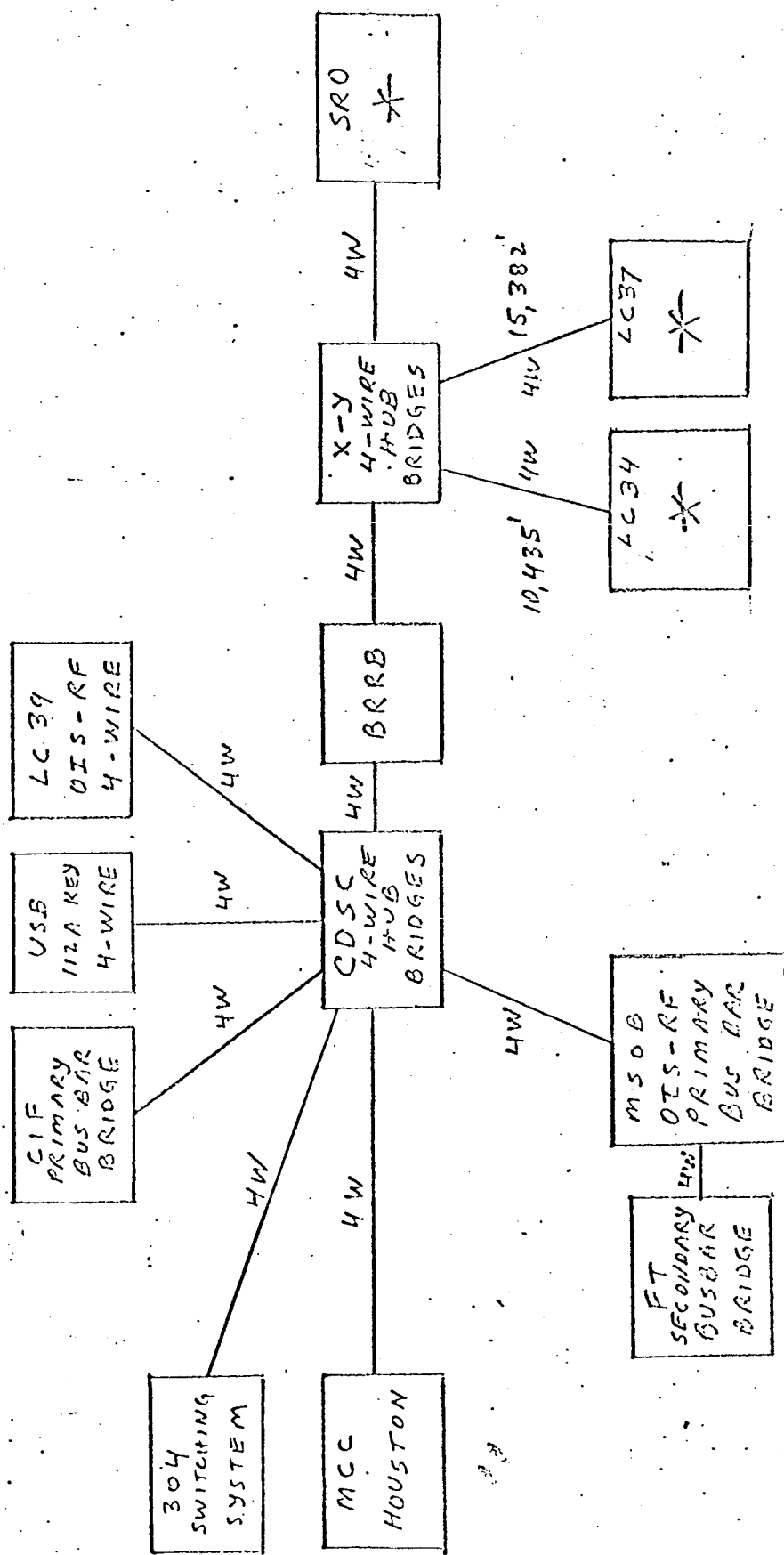


FOR OIS-A GET NOT USING 4W CKTS.

B = UNIFIED S BAND
 F = CENTRAL INSTRUMENT
 ATION FACILITY
 SOB: MANAGED SPACECRAFT
 OPERATION BLDG.

FIGURE 4
 PRESENT OIS-A
 AND OIS-RF CONFERENCE
 LAYOUT
 KENNEDY SPACE CENTER

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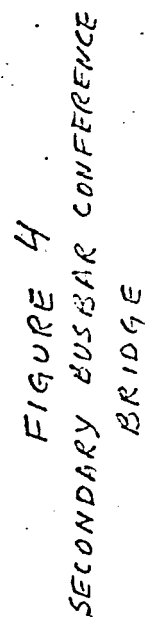


* PRIMARY AND SECONDARY
BUSBAR BRIDGES

FIGURE 2

GENERAL CONFERENCING
LAYOUT FOR 4-WIRE BRIDGES
CAPE KENNEDY SPACE CENTER

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COMPLEX A

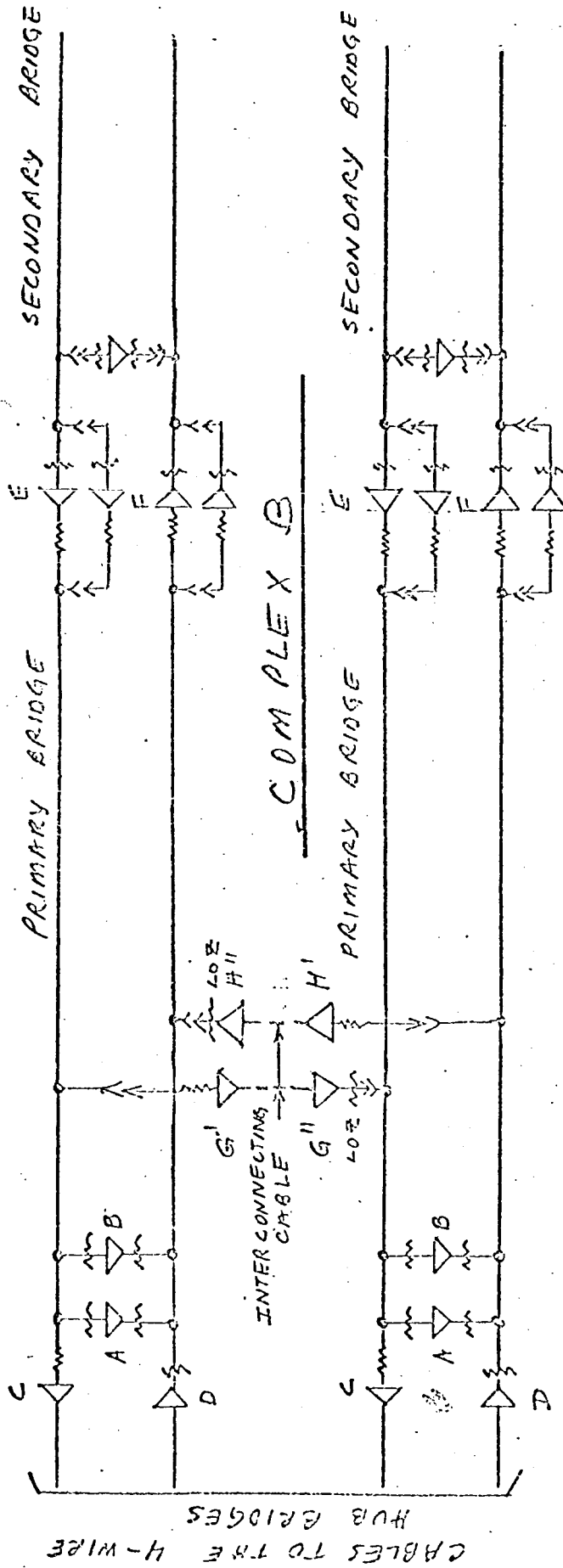


FIGURE 5
SUGGESTED METHOD
FOR
ADDITIONAL SERVICE PROTECTION

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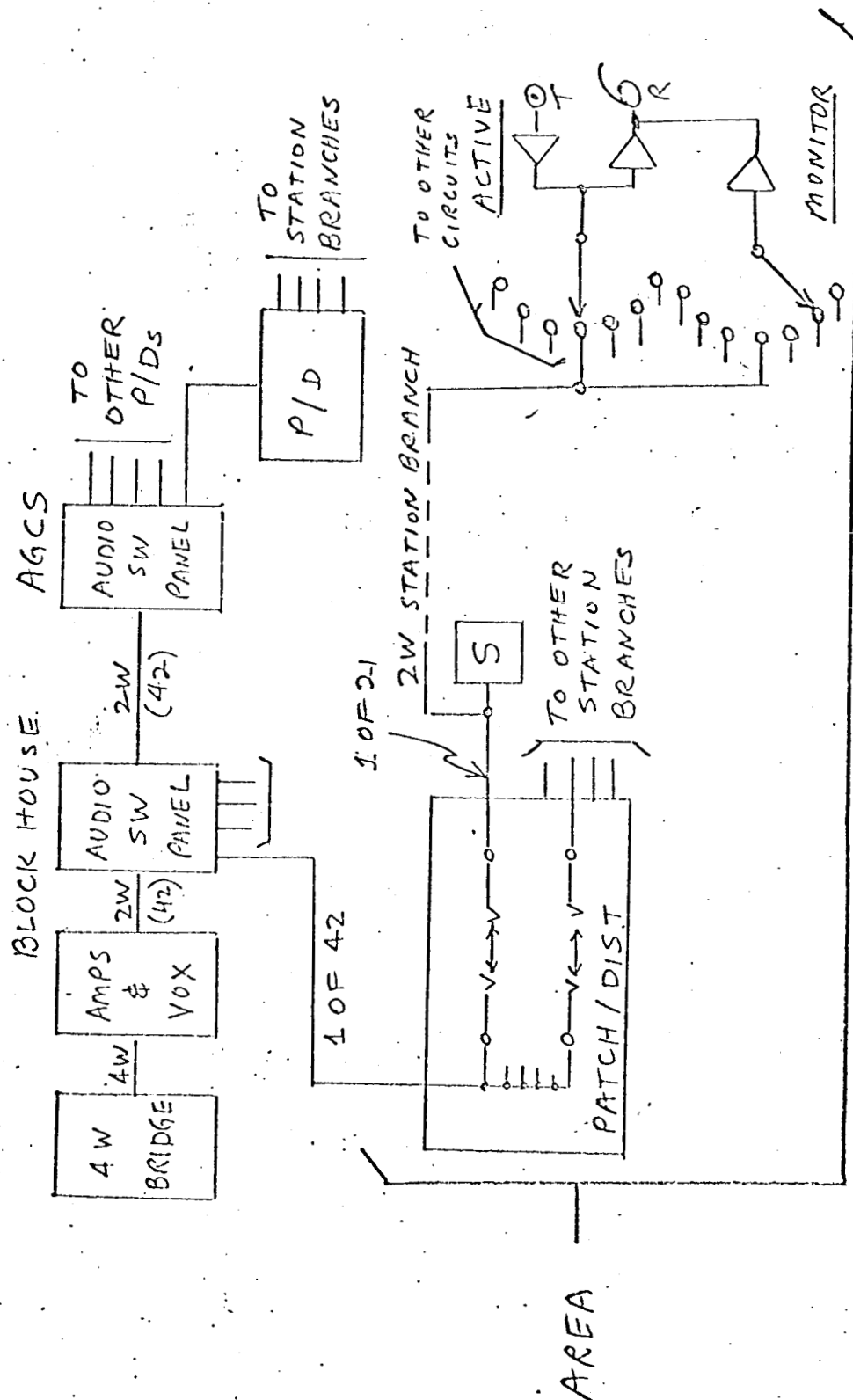


FIGURE 6
PRESENT CABLING
LAYOUT

5/25/67.

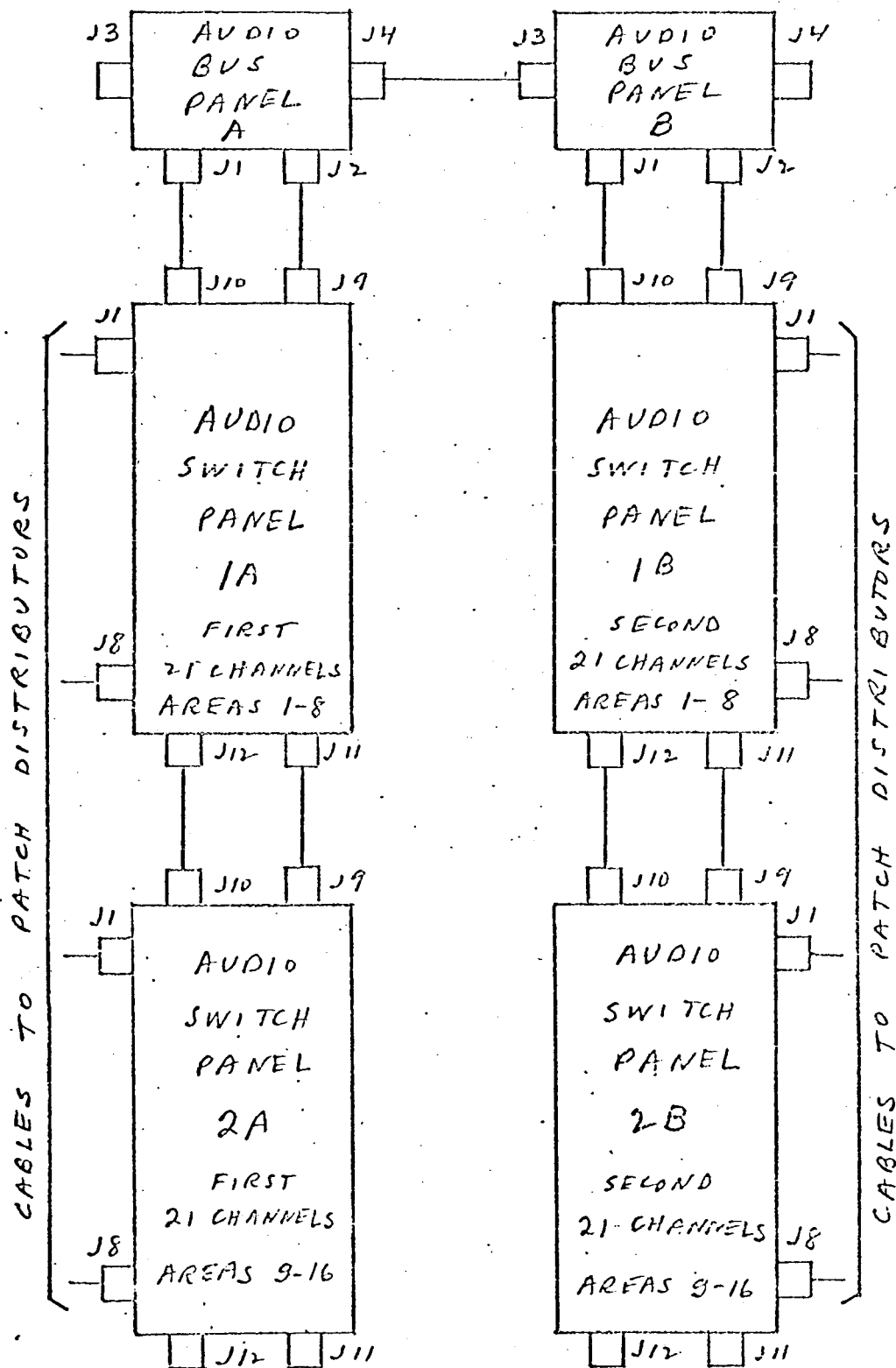


FIGURE 7
GENERAL PHYSICAL LAYOUT
OF AUDIO SWITCH PANELS
AND AUDIO BUS PANELS

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SWITCHES D & U
ARE IN AUDIO SWITCH OTHER BUILDINGS
PANELS

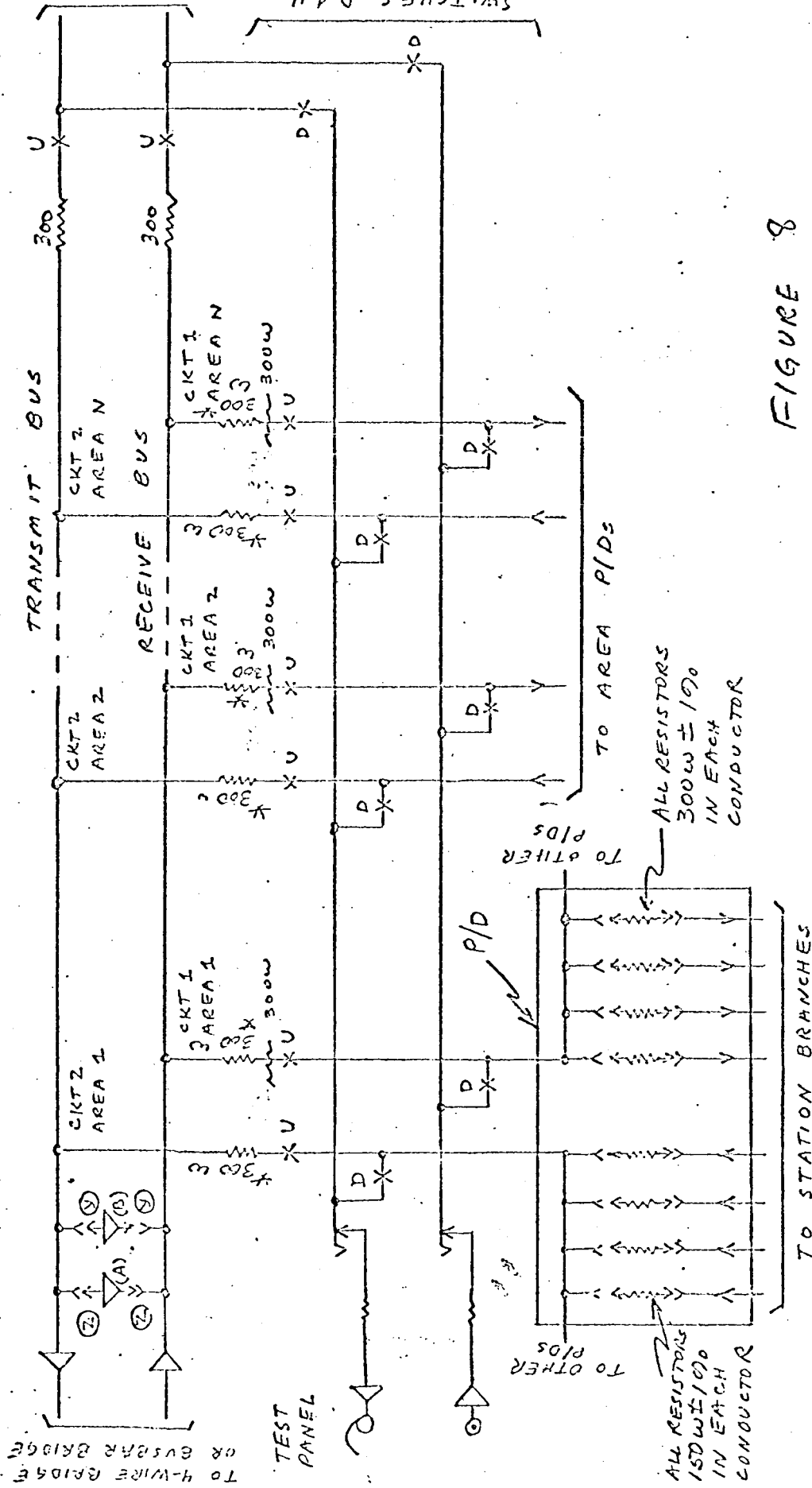
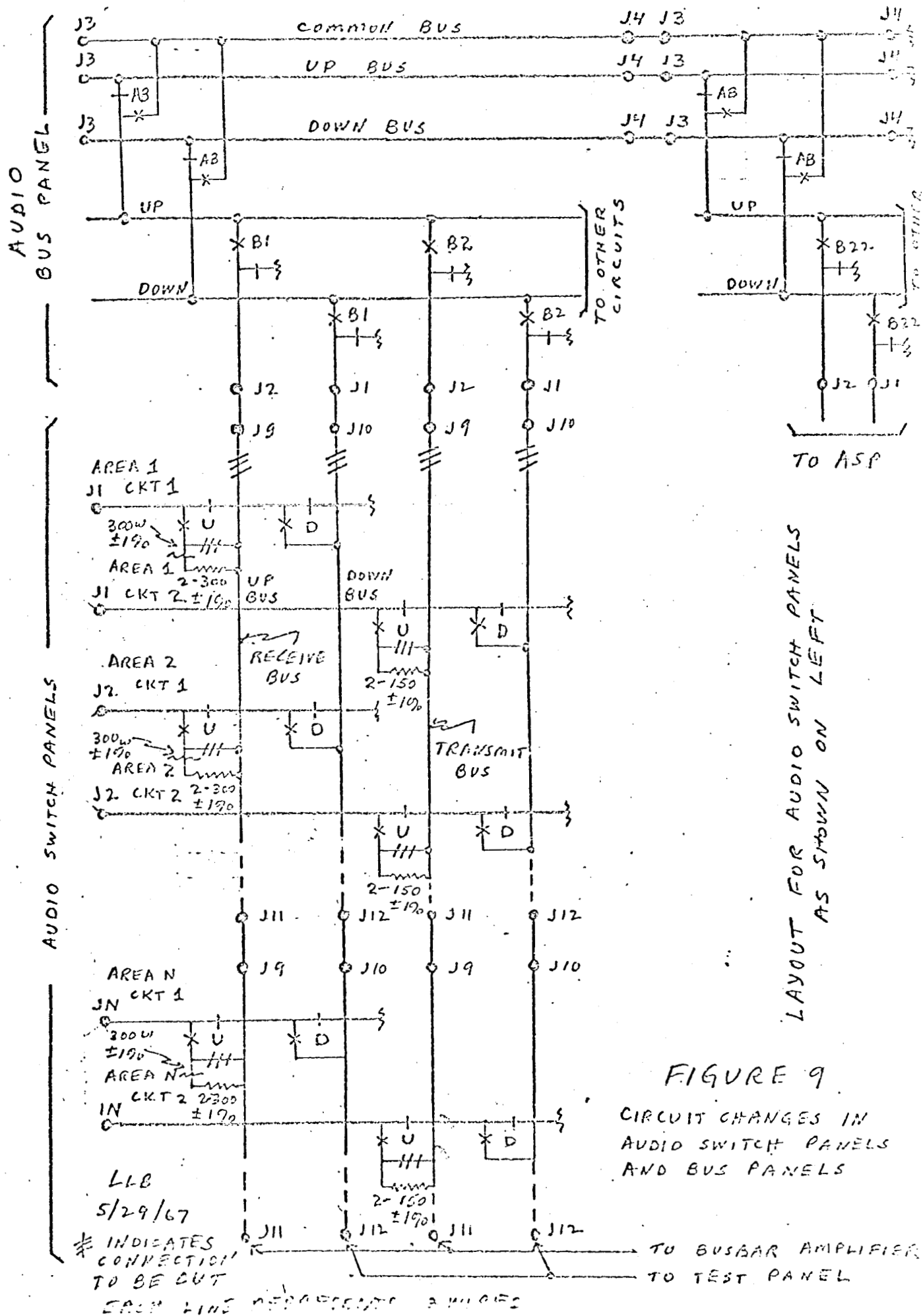


FIGURE 8
4-WIRE BUSBAR BRIDGE

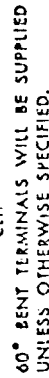
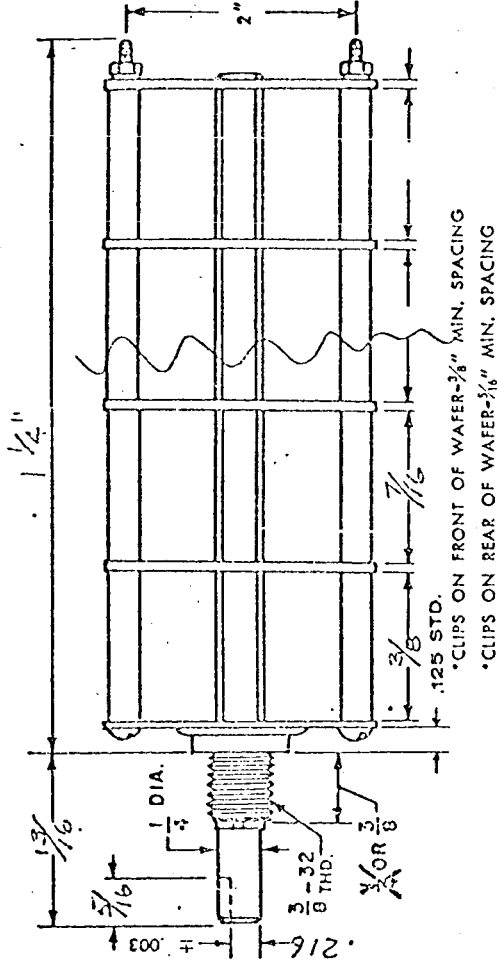
NOTES

EACH LINE REPRESENTS 2 WIRES
"U" INDICATES UP BUS
"D" INDICATES DOWN BUS
LLB 5/31/67
* 150W ± 10% IN EACH CONDUCTOR

PROVIDE (Z) AND (Y) OPTIONS FOR A PRIMARY BRIDGE
PROVIDE (Z) OPTION ON A PATCH BASIS FOR A



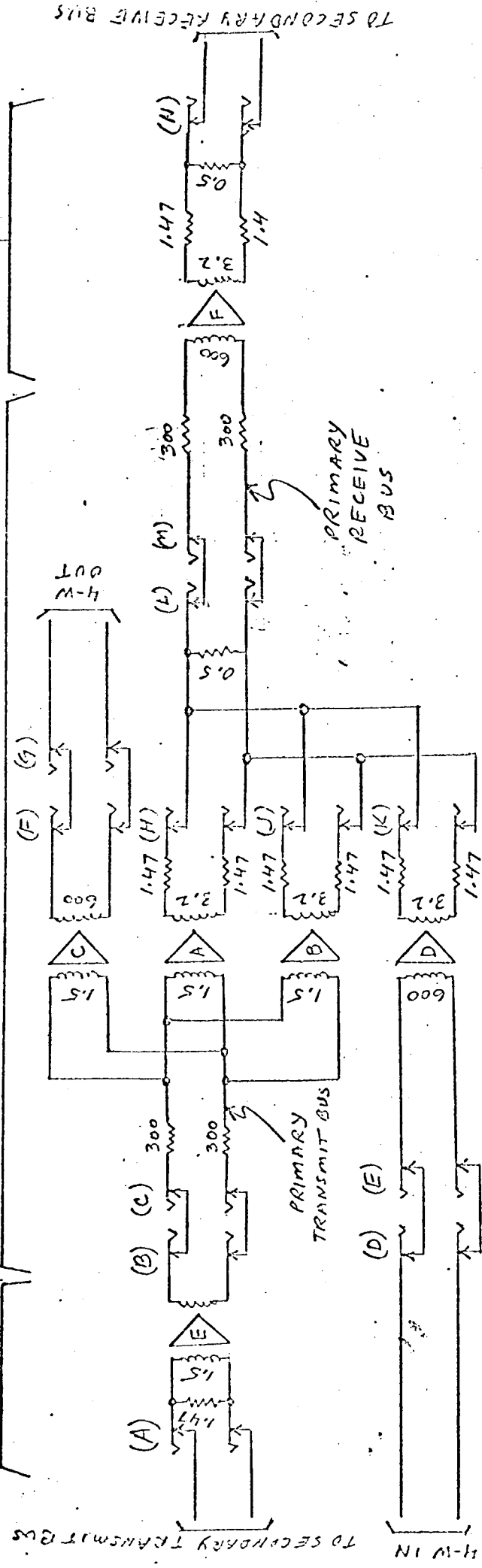
2 TO 24 POSITION .062 PHENOLIC



CHANGE AND DATE

AMPLIFIERS AND JACKS AT SECONDARY BRIDGE.

AMPLIFIERS AND JACKS AT PRIMARY BRIDGE



NOTE

JACKS SHOWN ARE TEST JACKS ONLY AND DO NOT TAKE INTO CONSIDERATION JACK REQUIRED FOR PATCHING AMPLIFIERS

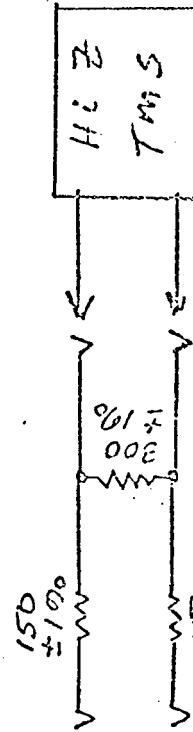
FIGURE 12.
TEST SETUP FOR PRIMARY AND SECONDARY BUSBAR BRIDGES

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SUGGESTED LINEUP PROCEDURE

STEP	OSCILLATOR		TRANSMISSION MEASURING SET				AMPLIFIER	
	Output dbm	In Series with	Connect To Jack	Set Z	In Series with	Connect To Jack	Open Jack	To Reader 600 Scale Adjust of TMS dbm
①	-0	600w	A	600w	0w	B	-	E
②	-5	0	C	600w	0w	F	-	C
③	-5	0	C	Hi Z	Net*	L	J	A
④	-5	0	C	Hi Z	Net*	L	H	B
⑤	-5	0	C	Hi Z	Net*	N	-	F
⑥	-20	0	E	Hi Z	Net*	L	-	D

FIGURE 13
SUGGESTED LINEUP
PROCEDURE



Network for
Test Use

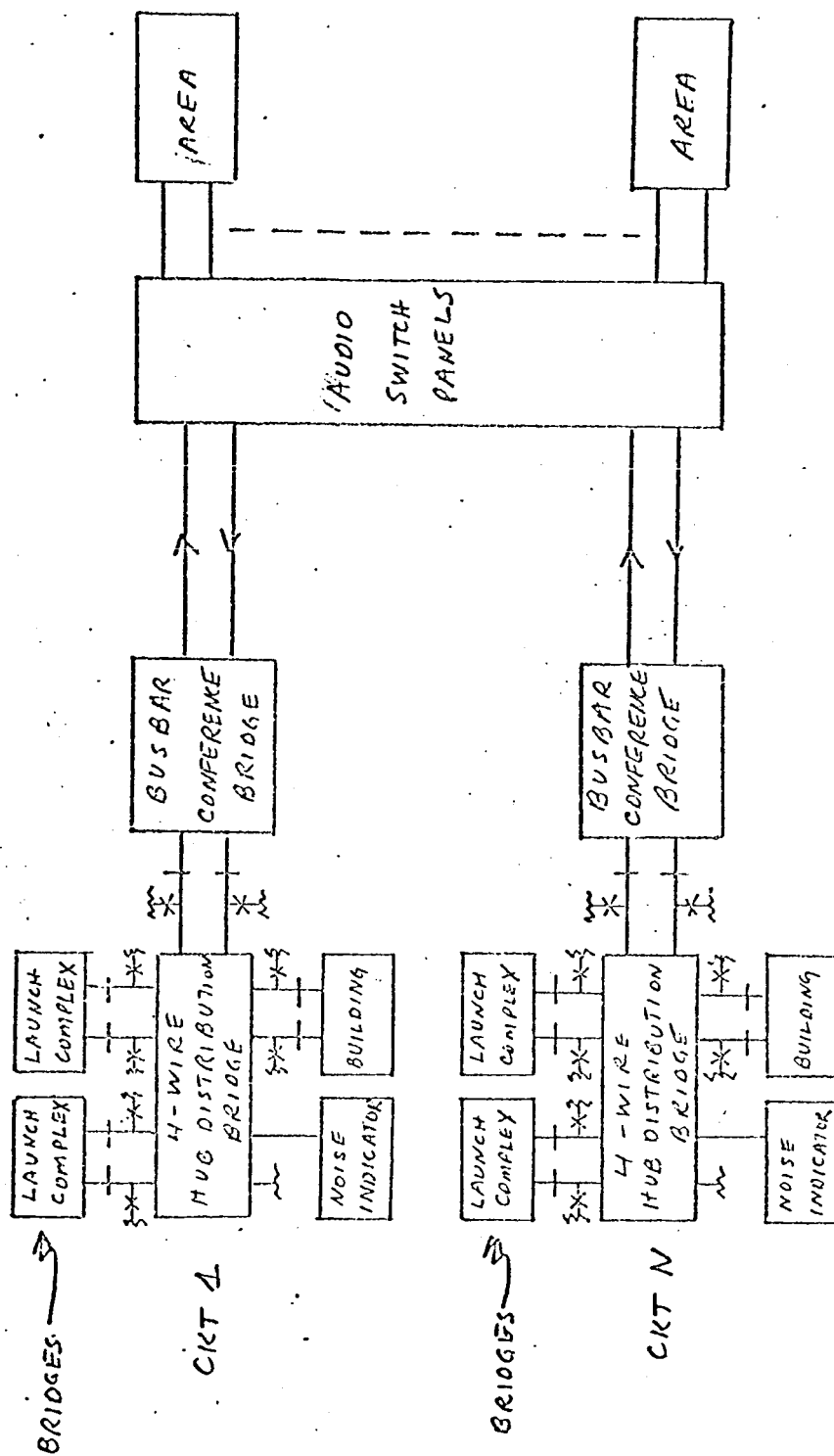


FIGURE 14
CONFERENCE LAYOUT
SHOWING NOISE
LOCATING EQUIPMENT

BRIDGE NO.	BRIDGE LEG NUMBER			
1	1	2	N-1	N
2	1	2	N-1	N

N-1	1	2	N-1	N
N	1	2	N-1	N

FIGURE 15
POSSIBLE TEST PANEL
AT
4-WIRE HUB BRIDGE
LOCATION

4B 5/2/67

ATTACHMENT B

KSC Conferencing System - Analysis of Transmission

May 26, 1967

The two wire conferencing arrangement at KSC consists of a multiplicity of stations bridged on a 600 ohm line. Since each user can at present choose up to 21 such conferences, the number of users on any given conference can change rapidly from a few to several hundred. With a significant amount of cabling capacitance and with the impedances of the existing station sets, the resulting level and frequency response of the system vary widely as the load varies.

During an investigation of the headsets in use at KSC it was discovered that headsets with up to 20 dB more gain than the present units could be obtained. If these headsets were used, at least part of the increased gain could be used to lower the bus impedance below 600 ohms. This would have two advantages: the frequency response of the system would be improved, and the variation in level with number of users would be decreased. In addition, the increased microphone gain would provide an improvement in signal to noise ratio. The purpose of this memorandum is to present estimates of the extent of these improvements in transmission.

Results

As shown in the following discussion, both bandwidth and level constancy would be significantly improved by using a 60 ohm bus with a transmitter and receiver each having 10 dB increase in gain. The decrease in received level with a change in number of users from 0 to 500 would be about 6 dB, compared with about 20 dB in the present system. The speech level with 500 users would be increased about 15 dB over the level in the present system. In addition, the use of new transducers and a 60 ohm bus resistance would reduce noise and crosstalk by between 10 and 20 dB. The distortion in the 60 ohm system would be less than in the present system, by operating further below the volume limiting point of the receive amplifier.

Discussion

In the following discussion it has been assumed that the existing amplifiers and cabling are used. The effects of various amounts of bus resistance and capacitance on both received speech level and frequency response is then determined. In estimating the received speech level use is made of loudness rating theory, which includes the weighted contribution of each frequency to loudness of speech. (See Appendix). It should be emphasized that two systems equally "loud" are not necessarily equally

intelligible; a system with a great deal of high frequency loss can be made to sound as loud as a flat bandwidth system, although many more words will be misunderstood in the system with high frequency loss. Since there is very little contribution to either loudness or intelligibility above (about) 3200 Hz or below 200 Hz, it is assumed that the headset receiver is restricted to this bandwidth.

In the following discussion one of the parameters of interest is the nominal bus resistance. As shown below, the resistance may be used to effect a gain-bandwidth trade. The system with the best frequency response and the least variation with loading is obtained by using the lowest possible bus resistance. This, however, lowers the speech output of the system. The resistance must be chosen, therefore, to satisfy the requirement of adequate volume under the worst condition of heavy usage, high cabling capacitance, and significant loss in the transmission path to the far end user. The no-load receive level of the present system appears to have at least 10 dB of margin. As discussed further below, speech on a heavily loaded system using 20 dB higher gain headsets and a 60 ohm bus would be heard about 6 dB below the present no-load speech level, an improvement of about 15 dB over the present 600 ohm system under the same conditions. In the final section, therefore, it is assumed that the worst-case speech level would be adequate

in a 60 ohm system, and the characteristics of this system are compared with those in the present system.

1.0 Bus Resistance

In a system in which all other gains or losses are held fixed, the bus resistance affects the frequency response of the system and the speech level. Assuming distributed cable capacitance can be represented as a lumped element C, a bus with resistance R will have a frequency - loss characteristic of

$$10 \log \left(1 + \left(\frac{f}{f_0} \right)^2 \right),$$

where f_0 is the frequency where the resistance and reactance are equal:

$$f_0 = \frac{1}{2\pi RC}.$$

The point where $f = f_0$ has been termed the "corner frequency"; at this point the response is down 3 dB. Since f_0 is inversely proportional to R, the larger R is, the lower the corner frequency, and the greater the attenuation through high frequency roll-off. This effect tends to decrease the speech level as R is increased. As shown in the Appendix, however, the gain of the system with negligible capacitance varies as $20 \log R$; the higher R is, the higher the output level. The relative contribution of these two effects depends on the cabling capacitance C. This effect is shown in Fig. 1, which gives the relative gain or attenuation from these two sources as a function of the bus resistance R. As shown on Fig. 1, a change in resistance from 60 ohms to 600 ohms would, with

zero capacitance, increase the system output by 20 dB. However, with 2- μ F of cabling capacitance, such a change would cause the perceived speech loudness to drop by 15 dB through increased high frequency attenuation. The net gain in such a case would be 5 dB. Fig. 2, which gives the relative frequency responses of the two systems, shows why this is so. As shown in Fig. 2, the frequency response with the higher impedance has a large slope across the band. The large slope would probably make this system poorer than the lower level system, even though it is 6 dB "louder".

The actual bus resistance is composed of the nominal resistance R_o plus the combined resistance of the station sets bridged on. Since the impedance of each set is approximately 30,000 ohms, the first few sets have little effect. As the combined resistance of the sets approaches the nominal bus resistance, the total resistance drops. The total bus resistance R is:

$$R = \frac{R_o}{1+n \frac{R_o}{30000}}$$

where n is the total number of users. Fig. 3 shows the variation in resistance for $R_o = 600,200$, and 60 ohms. The lower the value of R_o , the less relative change in R as n is varied. For example, as n increases from 0 to 500,

R in a 600 ohm system decreases from 600 ohms to 55 ohms, a change of 11:1. In a 60 ohm system, R changes from 60 to 30 ohms, a change of 2:1.

As the load increases and R decreases there are two opposing effects on the level, as shown on Fig. 1. The bandwidth improves, raising the level, while the gain decreases, lowering the level. With the exception of very large values of capacitance the net result is always a level decrease with increased loading, although the rate of decrease depends upon R_0 and C. In general, the level tends to drop roughly as $10 \log (1 + n R_0/30000)$ to the point where f_0 is greater than 3200 Hz, and then drops as $20 \log (1 + n R_0/30000)$ beyond this point. The amount of the variation with a given loading change is inversely proportional to R_0 , however. For example, with $R_0 = 600$ ohms the level drop can be as much as 20 dB in going from 0 to 500 users; with 60 ohms, the level drop under the same conditions is about 6 dB.

2. Comparison of Systems

In the following section a comparison is made between two systems: 1) the present 600 ohm system, and 2) a system in which the transmitter and receiver are both 10 dB more efficient than present units, and bus resistance has been lowered to 60 ohms.

2.1 Level Variation

Fig. 4 shows the variation in level with loading for the two systems for 15 μ F and 0.5 μ F of cabling capacitance. In all cases the receive level is referred to the no-load level, which is the same in the two systems. As shown on Fig. 4, the 60 ohm system would be much less affected by either cabling capacitance or loading than the present system. With 500 users, the received speech level in the 60 ohm system would be about 15 dB higher than in the present system.

2.2 Bandwidth

The 3 dB corner frequency with 60 and 600 ohms is shown versus loading in Fig. 5 for 1.5 μ F and .5 μ F. Fig. 5 assumes a receiver band limited to 3200 Hz. As shown in Fig. 5, with light loading the 600 ohm system has a corner frequency below 1000 hZ with 0.5 μ F of cabling capacitance; the 60 ohm system is not affected by 0.5 μ F. With 1.5 μ F, the 600 ohm case shows cut-offs of 200 to 300 Hz, implying a very bad response (see Fig. 2). The 60 ohm system is much less affected.

2.3 Noise

The use of a transmitter 10 dB more efficient than present units, combined with the expansion of the present amplifiers, will lower random noise from the amplifiers bridged on by about 14 dB. Pick-up of background

room noise depends upon number of open microphones and the characteristics of the microphones. Since one of the new microphones under consideration has 2 or 3 dB less noise cancellation than the present unit, the room noise picked up could be slightly higher. This microphone, however, suffers less variation in level with use, implying more constant speech level, so the net effect may be no increase in perceived noise or even a slight decrease.

2.4 Crosstalk and Interference

There are two sources of crosstalk: other two wire conferencing systems, and other outside sources (switching noise, machines, etc.) All of these sources can be considered high impedance sources, since the crosstalk coupling path is usually a small amount of capacitive coupling. The level of the cross-talking signal is therefore determined by the bus impedance. The level at which this signal is heard is determined by the gains and losses beyond the point where the cross-talking signal is introduced, which in turn are determined by the level of the wanted signal. Fig. 6 shows graphically the changes in signal level as the voice proceeds through the microphone, amplifiers and bus, and receiver in the present and in the 60 ohm systems. Since the intention of Fig. 6 is to show relative levels the amplifier gains are arbitrary, as shown by the broken lines. Each major division vertically corresponds to 10 dB. As

shown on Fig. 6, on wanted signals the increased transducer gain of 20 dB is balanced by the impedance change, so that speech is heard at the same level as before. Outside interferring signals are attenuated 20 dB by the impedance change, only 10 dB of which is counteracted by increased receiver gain. These signals are, therefore, reduced 10 dB over the present levels. The speech from other two wire conferences is attenuated by 10 dB on the bus carrying the conference; after unwanted coupling to an adjacent bus the change to 60 ohms causes another 20 dB of attenuation below the 600 ohm level. The increased receiver gain counteracts 10 dB of this attenuation for a net crosstalk reduction of 20 dB.

In all of the above cases the expansion of the receive amplifier has been ignored. If expansion is included, the reduction in outside crosstalk becomes about 15 dB, and from other 2 wire conferences about 26 dB.

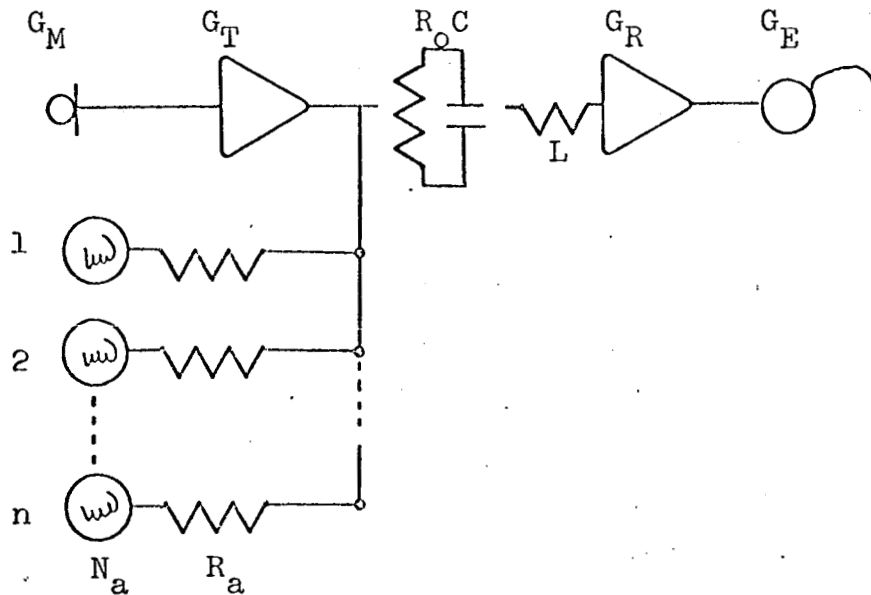
2.5 Distortion; Operating Point

A consideration in the KSC system is the operating point of the receive amplifier. At the present time these amplifiers are operated near the volume limiting point. This has the effect that speech of loud talkers decreases the gain of the amplifier; with the slow release time constant of these amplifiers both noise and other speech are

attenuated for a brief period. In addition, the distortion of the amplifier is higher close to the limiting point. In the 60 ohm system speech is received at the input to the amplifier about 10 dB lower than at present, providing considerable margin against unwanted compression.

APPENDIX

The assumed model of the two-wire conferencing system is shown below:



G_M = microphone gain

G_T = transmit amplifier gain

G_R = receive amplifier gain

G_E = earphone gain

R_o = bus resistance

R_a = resistance of station

C = cabling capacitance

N_a = output random noise of amplifier

L = average cabling loss

n = number of stations bridged on

All gains are power gains. Since the output of the transmit amplifier and the input of the receive amplifier are both high impedance the bus voltage is determined only by the bus impedance. Thus, in terms of the power delivered

to the ear the gain of the transmit amplifier can be defined as $G_T + 20 \log R$, where G_T is a constant (for a given input) and R is the combination of R_o and n stations, each of resistance R_a . Since both amplifiers have expansion characteristics for noise rejection their gains increase with signal level; for simplicity the expansion is assumed linear in dB, i.e., $G_T = G_{To} + k_T (\text{signal in})$ and $G_R = G_{Ro} + k_R (\text{signal in})$, where k_T and k_R are constants. Ignoring the capacitance for a moment, therefore, the total signal out, S , for an input S_o is:

$$S = ((S_o + G_M) k_T + G_{To} + 20 \log R - L) k_R + G_{Ro} + G_E$$

The total noise output is the (rms) combination of n noise sources of N_a each feeding the bus through a high impedance. Again in terms of the power delivered to the ear, therefore, the random noise output is:

$$N = (N_a + 10 \log n + 20 \log R - L) k_R + G_{Ro} + G_E$$

The signal-to-noise ratio is, therefore:

$$S/N = k_R ((S_o + G_M) k_T + G_{To} - N_a - 10 \log n)$$

It should be noted that the signal-to-noise ratio is not a function of bus resistance R . If the use of new transducers with improved gain is balanced by a lowered bus impedance so that the output, S , remains constant for a given input, the signal-to-noise ratio will increase (i.e., the output noise decrease) by:

$$k_R k_T (G'_M = G_M)$$

where $G'_M - G_M$ is the increase in microphone efficiency, 10 dB. The specifications call for K_T and K_R of between 1.6 and 2, although BTL measurements on limited samples show values closer to 1.2. Using the lower value, a noise reduction of about 14 dB would occur.

Loudness rating theory predicts the perceived level of any given system according to the relationship

$$V = 44 \log \left[\int_{f_1}^{f_2} \frac{R(f)^{1/2.2} df}{f} \right]$$

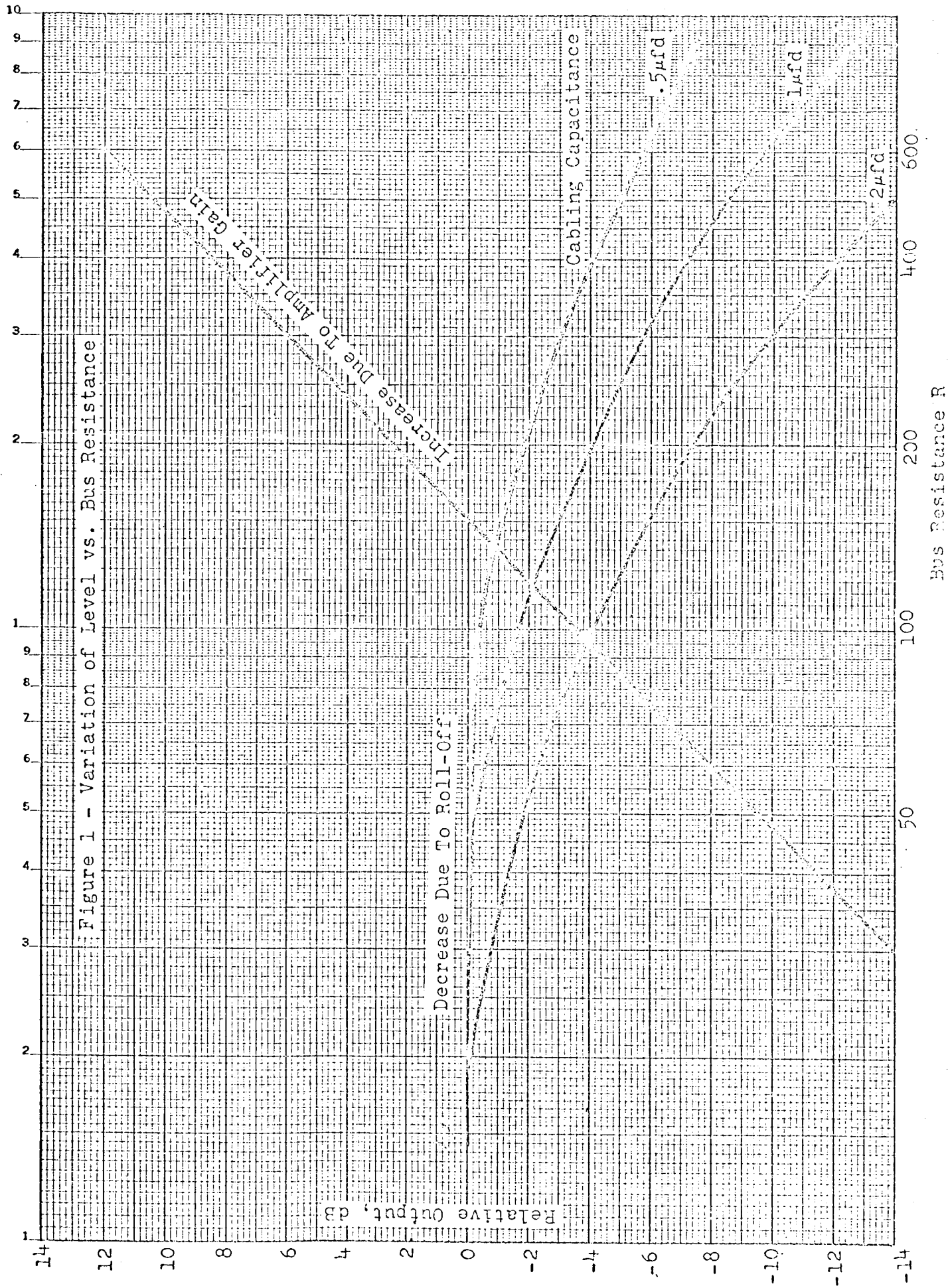
where V is the loudness rating, and $R(f)$ is the frequency response between limits f_1 and f_2 . With a bus resistance R and capacitance C ,

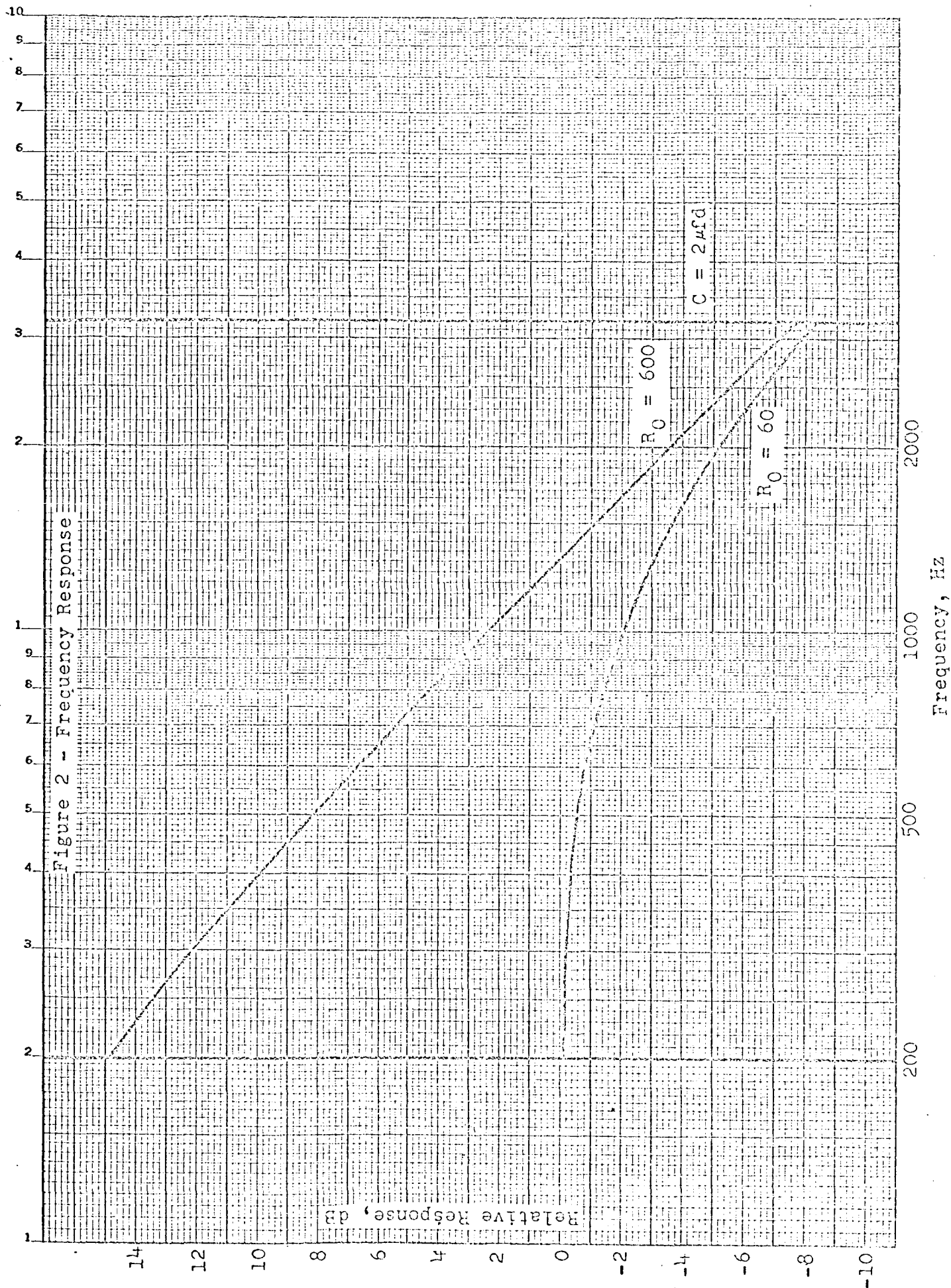
$$R(f) = \frac{1}{\sqrt{1 + (f/f_0)^2}},$$

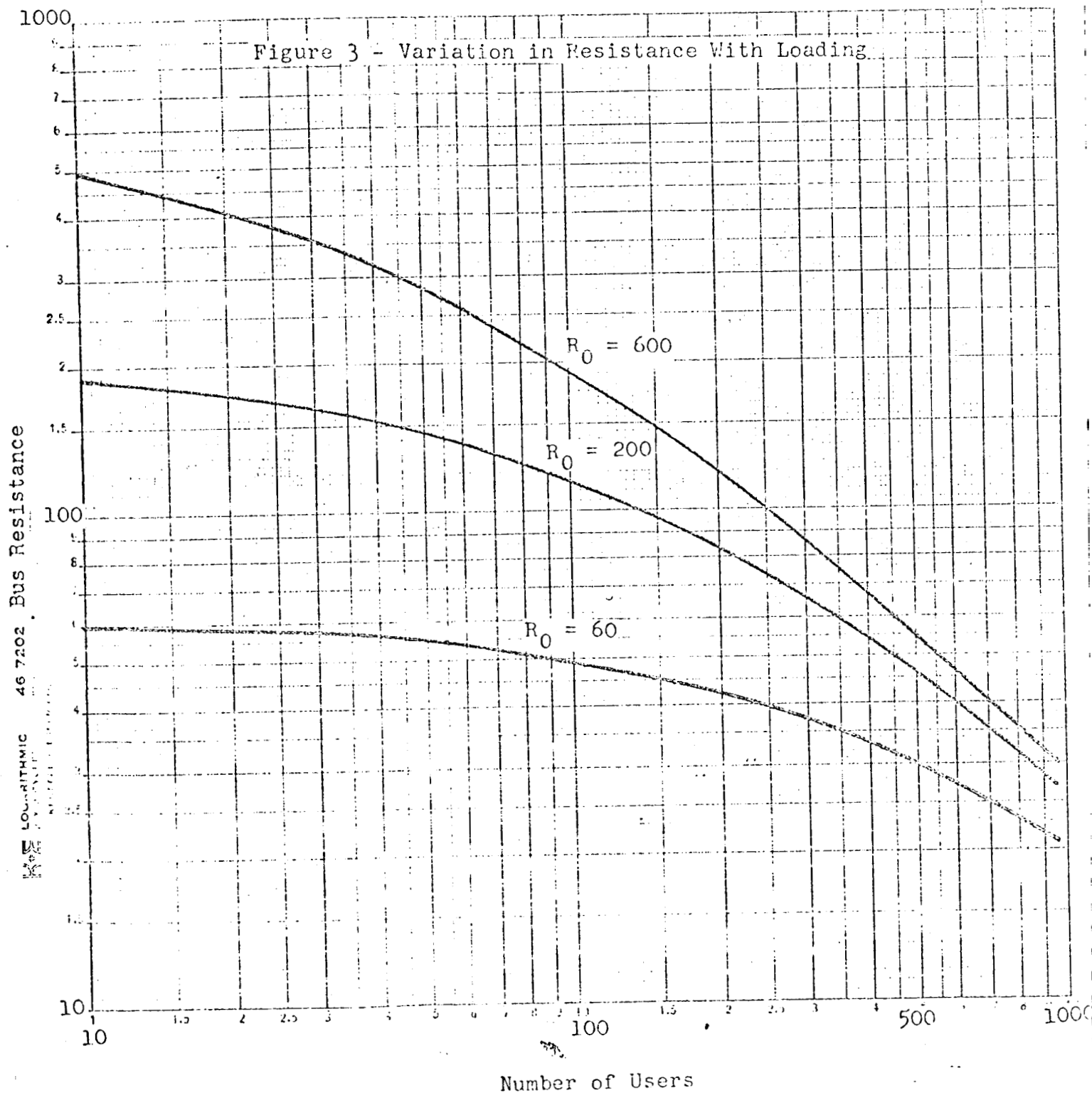
$$f_0 = \frac{1}{2\pi RC}.$$

Since actually carrying out the above integration is very involved, the rating V is most readily obtained by numerical integration. The results of such an integration are used in plotting Fig. 1.

Figure 1 - Variation of Level vs. Bus Resistance







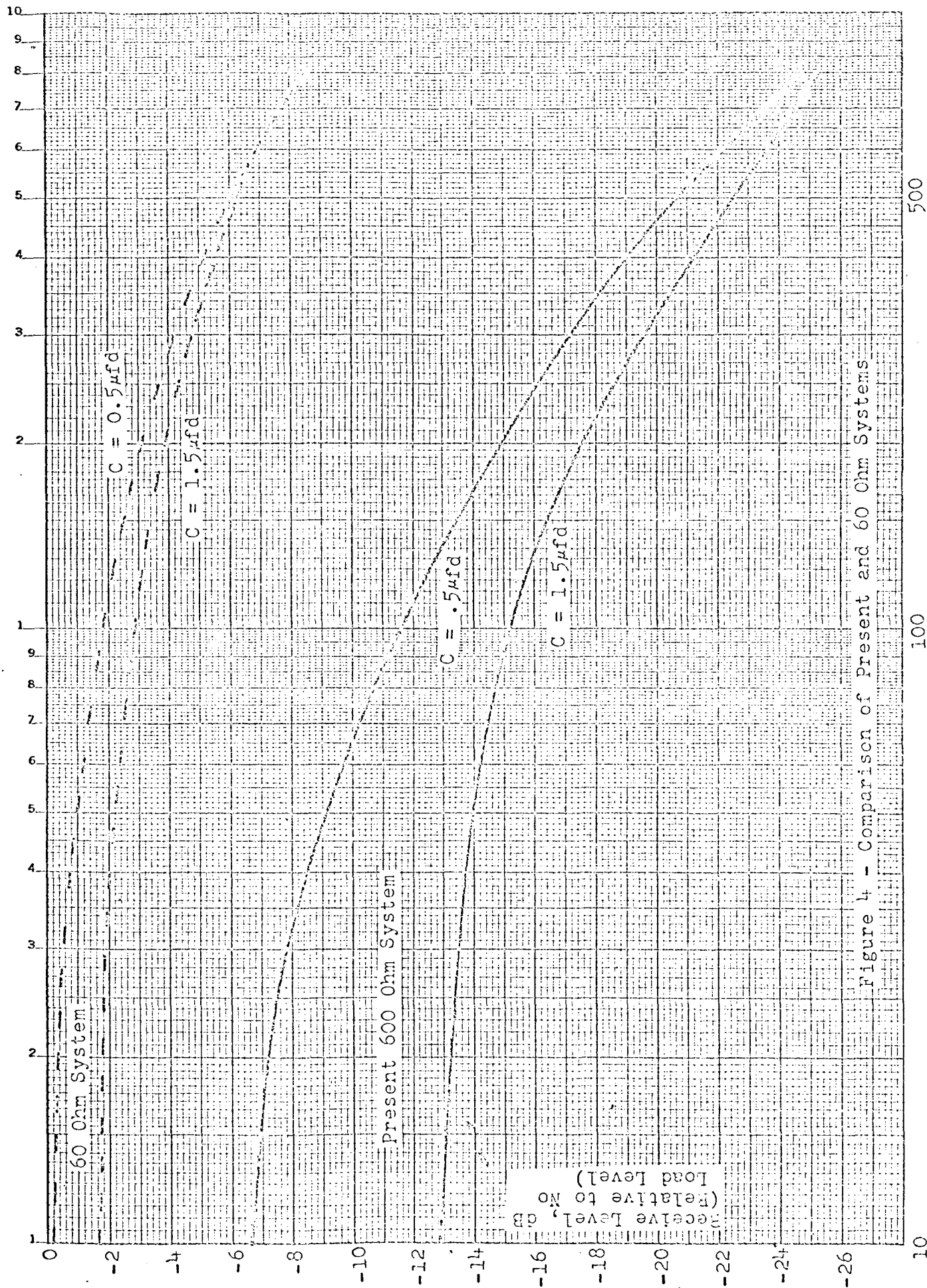


Figure 4 - Comparison of Present and 60 Ohm Systems



Figure 5 - Corner Frequency vs. Load

100

Number of Users

1000

